

Abstract

Pain has the capacity to interfere with daily tasks. Although task interference by pain is largely unintentional, it can be controlled to a certain extent. Such top-down control over pain has been thought to be reduced in fibromyalgia patients. In this study, we investigated task interference and distraction efficacy in fibromyalgia patients (FM) and a matched healthy control group. Forty-nine fibromyalgia patients and 49 healthy volunteers performed as quickly as possible (a) a visual localization task in the presence of non-painful vibrating or painful electric somatic stimuli, and (b) a somatosensory localization task (using non-painful or painful stimuli). Participants reported on their experience of the somatic stimuli on some of the trials during both localisation tasks. Results indicated that pain interferes with performance of the visual task, in both FM patients and healthy individuals. Furthermore, participants experienced the pain stimulus as less intense when directing attention away from the pain than when focusing on the pain. Overall, task performance of FM patients was slower compared to the task performance in the healthy control group. In contrast to our hypotheses, FM patients and healthy volunteers did not differ in the magnitude of the interference effect and distraction-efficacy. In conclusion, current study provides support for contemporary theories claiming that attention modulates the experience of pain and vice versa. However, no evidence was found for an altered attentional processing of pain in fibromyalgia patients. Furthermore, results indicate that task interference and distraction-efficacy are not just two sides of the same coin.

Introduction

A key feature of pain is its ability to demand attention [15,57]. In acute pain, this feature is adaptive as it urges a person to escape from bodily threat [15]. In the long-term, however, this ability may become maladaptive as pain interferes with the capability to fulfil daily tasks and goal pursuit [16,18,49]. The interference of pain with task performance has been documented in healthy individuals experiencing acute pain (e.g., [3,6,9,35]) as well as in those with chronic pain (e.g., [14,37]). Whereas the capture of attention by pain may be largely unintentional, it can be controlled to some extent. Indeed, several studies have shown that directing attention away from pain by engaging in a task unrelated to pain (i.e., attentional distraction) reduces acute pain and related distress [5,7,17,23,24,33].

The answers to the questions “How and when does pain interfere with ongoing tasks” (task interference), and “how and when does directing attention away from pain diminishes pain (distraction efficacy)” are often grounded in similar theoretical frameworks (e.g., [10,15,29,]). Nevertheless, only few studies have simultaneously investigated task interference and distraction efficacy (see [42] for an exception). Furthermore, these frameworks often (implicitly or explicitly) assume that the magnitude of both phenomena is altered in people with chronic pain [19,29,37]. Research comparing task interference and/or distraction efficacy between healthy participants and chronic pain patients is however largely lacking. The need for further research comparing both phenomena has been emphasised in a recent meta-analysis summarizing available work on the effects of distraction in chronic pain patients [54]. In contrast to research in healthy volunteers, available research in chronic pain patients suggests that directing attention away from pain does not reduce pain and distress. Notwithstanding, more research is needed because the available evidence consisted largely of studies that did not include healthy control groups, used small samples and suffered from methodological shortcomings (e.g., no control for alternative coping strategies in the control condition). If proven, distraction inefficacy in chronic pain patients may point at the presence of (a) heightened levels of vigilance for pain and/ or somatic sensations in general [11,12,57] or (b) problems of executive functioning in chronic pain patients [4,37]. Both

explanations have been put forward to explain the failure of distraction in chronic pain patients [25,28,56].

In the current study, we investigated, both, task interference and distraction efficacy in a sample of fibromyalgia (FM) patients and a matched healthy control group. FM patients were selected because previous research suggests that they are prone to impairments of attention and show reduced levels of executive functions (e.g., [47]). We hypothesized that (a) pain would interfere with task performance in healthy participants and FM patients, albeit to a larger extent in FM patients; (b) directing attention away from pain would reduce the experience of pain in healthy volunteers, but not or to a lesser extent in FM patients, and (c) pain intensity would affect the magnitude of task interference and distraction efficacy. For exploratory purposes, we also examined the relationship between distraction efficacy, task interference, and their relationship with other constructs presumed to play a role in both phenomena.

Method

Participants

The study sample ($N = 98$) consisted of FM patients ($N = 49$) and healthy volunteers ($N = 49$) aged between 18 and 65 years, who were recruited for the ASEF-I-project. Within the ASEF-I-project, a group of FM patients and a matched group of healthy participants were recruited to investigate attention and self-regulatory processes. The full project protocol, detailing the study design and flow can be retrieved via following link: <http://hdl.handle.net/1854/LU-5686902>. Recruitment of participants took place between January and March 2014. Participants were only included if they (1) had sufficient knowledge of the Dutch language; (2) did not suffer from a neurological condition; (3) could use both index fingers; (4) did not report abnormal sensations in the arms; (5) had a normal or corrected-to-normal (e.g., by glasses) eyesight; (6) were not pregnant; and (7) did not have a pacemaker. In addition, FM patients were only included if they had received a FM diagnosis and fulfilled the American College of Rheumatology (ACR)-2010-criteria [58], and healthy participants if they did not report a current pain problem. FM patients and healthy participants were matched at group level for age, sex and educational level. FM patients

were recruited in the Multidisciplinary Pain Clinic of Ghent University Hospital. They were informed about the study via a poster in the waiting room of the hospital. Patients who were interested in taking part left their contact details. The healthy control group was recruited via advertisements in a local newspaper, flyers and the university website. Healthy participants who fulfilled the eligibility criteria were contacted by telephone and informed about the study. For participants who agreed to participate, an appointment was scheduled for a laboratory session. A flow chart indicating the exact number and reasons of non-participation of participants can be found in the full study protocol of the ASEF-I-project. The study was approved by the medical ethics committee of the University Hospital of Ghent (registration number: 2013/1016).

Apparatus and somatosensory stimuli

Somatosensory stimuli consisted of painful and non-painful stimuli. Non-painful stimuli were tactile stimuli (frequency = 200 Hz; duration = 300 ms; intensity = 0.07 Watt) and presented with two resonant-type tactors (C-2 TACTOR, Engineering Acoustics, Inc., Florida) consisting of a box of 3.05 cm diameter and 0.79 cm height, with a skin contactor of 0.76 cm diameter. Painful stimuli were electrocutaneous stimuli (bipolar; 50 Hz; 300 ms; instantaneous rise and fall time) delivered by a constant current stimulator (DS5, Digitimer Ltd, Hertfordshire, United Kingdom). All somatosensory stimuli were delivered in the region of the medial cutaneous nerve of the left forearm (close to wrist or close to the elbow; see figure 1)

Self-report measures

Fibromyalgia symptoms were assessed using the widespread pain index (WPI) score, which represents a number of whole-body pain areas (max score = 19), and the symptom severity (SS) score that quantifies symptom severity on a 0-12 scale by scoring problems with fatigue, cognitive dysfunction and unrefreshed sleep over the past week. In line with the 2010 ACR criteria [58], participants satisfied the fibromyalgia criteria if they had a (1) WPI score greater than or equal to seven and a SS score greater than or equal to five or (2) a WPI score ranging from three to six and a SS score greater than or equal to nine.

Pain severity was assessed with the pain severity subscale of the Multidimensional Pain Inventory (MPI; [26,31]). The MPI (Part 1) consists of five subscales assessing the impact of pain on a 7-point Likert scale ranging from 0 to 6. Pain severity was assessed with two items (i.e., “Rate the level of your pain at the present moment” and “On average, how severe has your pain been during the last week?”). In line with previous studies, the third item (“How much suffering do you experience because of your pain?”) of the pain severity subscale was not taken into account given that its content relates to suffering rather than pain severity (see also [40,53]). The MPI has shown good reliability and validity [43]. In the present study, Cronbach’s alpha of the MPI severity subscale was .84.

Pain-related disability was measured with the Pain Disability Index (PDI; [41]) which assesses the level of restriction in participation in seven life domains (e.g., family) on a scale ranging from 0 (no disability) to 10 (total disability). Participants were asked to evaluate the overall impact of pain (not just when pain is at its worst) on each of the seven life domains, on a scale from 0 to 70. Cronbach’s alpha of the PDI was .82.

Depressive mood, anxiety and stress during the past week were assessed using the Depression Anxiety Stress Scales (DASS; [32]). Each sub-scale contains 14 items (e.g. “I found it hard to wind down”, “I felt I was pretty worthless”), which were rated on a 4-point Likert scale ranging from 0 (“*did not apply to me at all*”) to 3 (“*applied to me very much, or most of the time*”). In the present study, Cronbach’s alpha for the depression, anxiety and stress subscales were respectively .96, .91 and .95.

Pain catastrophizing was assessed using the Pain Catastrophizing Scale (PCS; [46]). This scale contains 13 items that measure catastrophic thoughts about pain in both clinical and non-clinical samples. To answer these items participants are required to think about past painful experiences and indicate on a 5-point scale (ranging from 0 [“not at all”] to 4 [“always”]) the degree to which they experienced each of the 13 thoughts or feelings (i.e. “When I’m in pain it’s terrible and I think it’s never going to get any better”). Research has shown that the PCS is valid and reliable [48]. In the present study Cronbach’s alpha of the total PCS score was .95.

Vigilance for bodily symptoms was measured using the Body Vigilance Scale (BVS; [44]). The BVS is a 4-item questionnaire measuring vigilance for bodily symptoms on a 11-point numerical rating scale (e.g., “I am very sensitive to changes in my internal body sensations”). The last item is an average of the awareness scores of 15 non-specific body symptoms (e.g., “rate how much attention you pay to each of the following sensations [e.g., heart palpitations, tingling, nausea]”). Cronbach's alpha of the four BVS-items in this study was .73.

Experimental task

The experimental task was programmed and presented using the INQUISIT Millisecond software package (Inquisit 3; Seattle, WA: Millisecond Software) on a Dell computer (Intel Core2 Duo P8600, 4096MB) with a 60-Hz, 17-inch colour CRT monitor. The experiment consisted of localizing either the somatosensory stimuli (non-painful, low painful, moderately painful) during a somatosensory localisation task (somatosensory focus task), or the visual stimuli during a visual localisation task (visual focus task = distraction task). Somatosensory and visual stimuli were simultaneously presented during each trial. In 50% of the trials, participants were instructed to localize as quickly as possible whether the visual stimulus (i.e. 1cm x 1cm black square) was presented to the left or right side of the screen (visual focus trials). On the remaining trials, participants were instructed to localize as quickly as possible whether the somatosensory stimulus was presented to the left (close to the elbow) or right (close to the wrist) location on the left arm (somatosensory focus trials). Each trial started with a visual cue consisting of a full coloured circle (either blue or yellow; 1000 ms duration) in the centre of the screen that indicated which modality was relevant and needed to be attended to. Somatosensory and visual stimuli were presented the same number of times at the left and right location. A total of 256 trials were presented. In 192 (75%) trials, the somatosensory stimulus consisted of non-painful tactile stimuli. In the other 64 (25%) trials, the somatosensory stimulus consisted of painful electrocutaneous stimuli (32 trials with low intense pain and 32 trials with moderately intense pain). Furthermore, 25% of the non-painful trials (i.e., 48 trials) and 75% of the painful trials (i.e., 48 trials) were followed by two visual analogue scales (“How intense was the last somatosensory stimulus” [0 = totally not intense;

10 = very intense]; “How unpleasant was the last somatosensory stimulus” [0 = totally not unpleasant; 10 = very unpleasant]) that probed the intensity and the unpleasantness of the experienced pain. Trials with vibrotactile stimuli were implemented for several reasons. First, somatosensory trials were included as a control category to investigate the magnitude of task interference by pain. Second, the inclusion of somatosensory trials reduced the overall percentage of trials that were followed by a pain rating. Hence, the possibility that participants attended to the somatosensory stimuli during visual modality trials because they expected to rate the somatosensory stimuli was kept low (see also [51]). This resulted in six trial types: (1) non-painful somatosensory focus trials, (2) low painful somatosensory focus trials, (3) moderately painful somatosensory focus trials, (4) non-painful visual focus trials, (5) low painful visual focus trials, and (6) moderately painful visual focus trials. Each trial type was presented ‘equi-probably’ and randomly at the left and right location. Participants indicated the location of the stimuli using the right hand on the keyboard (4 = left; 6 = right) (see Figure 1 for a schematic presentation of the study set-up).

Procedure

Prior to the experimental session (i.e., before scheduling the laboratory session and providing general study information), all participants were asked to complete a number of questionnaires at home (including the MPI, DASS, PDI, BVS, PCS, demographic information), either online (via LimeSurvey) or on paper. Upon arrival, all participants received additional information about the study and signed an informed consent form. Thereafter, all participants performed several experimental tasks as part of the ASEF-I project. The experimental task described in the current study was the first (after ACR-criteria assessment and a 10-minute resting period during which heart-rate was monitored) that people performed. Before starting the experimental task, participants filled out how intense the pain was (VAS ranging from 0 = no pain to 100 = worst imaginable pain) and how much fatigue (VAS ranging from 0 = not at all to 100 = very much) they experienced at that moment. Furthermore, participants received the following information “During this task non-painful and painful stimuli will be administered. The intensity of the stimuli may

differ more or less from each other.” After receiving this information, the left arm of the participants was scrubbed and two lubricated Technomed Europe surface electrodes (Maastricht, The Netherlands; 1 cm diameter) and two resonant-type tactors (C-2 TACTOR, Engineering Acoustics, Inc., Florida) were attached at two locations of the left forearm (close to the wrist or the elbow) situated in the medial cutaneous nerve area. Next, the intensity of the electrocutaneous stimuli was individually determined for each participant by administering electrocutaneous stimuli of increasing intensity at both locations of the arm (starting with 0.5 mA) and increasing with steps of 0.5mA. During the calibration phase, participants were instructed to pay close attention to the pain stimulus when judging its intensity. The intensity of the electrocutaneous stimulus increased until participants reported that the pain stimulus they received was of moderate pain (on a scale ranging from “no pain”, “little pain”, “moderate pain”, “intense pain”, “enormous pain” and “unbearable pain”). This moderately intense pain stimulus was then used during the experimental task. A so-called ‘low intense pain’ stimulus was derived from the moderately intense pain stimulus using the formula provided by Arntz and colleagues [2]. This procedure resulted in an overall mean objective stimulus intensity of 3.79 mA ($SD = 2.02$) and 3.56 mA ($SD = 1.97$) for the left and right moderately intense pain stimulus, respectively and an overall mean objective stimulus intensity of 3.38 mA ($SD = 1.82$) and 3.18 mA ($SD = 1.78$) for the left and right low intense pain stimulus. The objective stimulus intensity did not differ significantly between locations (All $F_{(1, 96)} < 2.35$, ns), but did differ between groups (moderately intense pain stimulus: $F_{(1, 96)} < 28.25$, $p < .001$; low intense pain stimulus: $F_{(1, 96)} < 28.03$, $p < .001$), indicating that the objective intensity of the pain stimuli was lower for FM patients (moderately intense pain stimulus: $M = 2.79$ mA, $SD = 1.35$; low intense pain stimulus: $M = 2.49$ mA, $SD = 1.22$) than for healthy controls (moderately intense pain stimulus: $M = 4.56$ mA, $SD = 1.89$; low intense pain stimulus: $M = 4.07$ mA, $SD = 1.71$).

- INSERT FIGURE 1 ABOUT HERE -

Data analyses

Statistical analyses were performed with SPSS statistical software, version 24.0 for Windows (SPSS Inc., Chicago, IL). Analyses investigating task interference by pain in healthy participants and FM patients were performed on the response latencies of distraction (i.e. performance of the visual task) trials only, using a repeated measures analysis of variance (ANOVA) with Somatosensory Stimulus (non-painful vs low painful vs moderately painful) and Group (healthy controls vs FM patients) as a between-group factor. Contrast analyses were used to investigate the effect of pain intensity upon the magnitude of task interference. Analyses investigating distraction efficacy in healthy participants and FM patients were performed on pain intensity and unpleasantness ratings of the painful stimuli only. Pain intensity and unpleasantness ratings of the vibrotactile stimuli were not analyzed (see above). For each dependent variable (pain intensity and unpleasantness), a repeated measures ANOVA with Pain Stimulus (low painful vs moderately painful) and Modality Relevance (somatosensory relevant/ visual relevant) as within-subject factors and Group (healthy controls vs FM patients) as between-group factor was conducted. When appropriate, contrast analyses were used.

For all analyses, Greenhouse–Geisser corrections (with adjusted degrees of freedom) were performed whenever the sphericity assumption was violated (Mauchly test of sphericity was $p < .05$). Furthermore, the cut-off for statistical significance was set at $p < .05$, and effect sizes were reported using the partial eta squared index (η_p^2) and when appropriate Cohens' d (see also [8,27,39]).

Results

Descriptives

Mean age of participants was 45.30 years ($SD = 10.74$; range 22- 65 years), and 81 of them were female (82.7%). The majority of the participants was married or living together (55.1%). Almost half of the sample graduated from high school or university (45.9%). For FM patients, the mean pain duration was 186.36 months ($SD = 115.14$). The two groups did not differ in terms of age, sex distribution or educational level (see Table 2 for an overview). FM patients reported a mean pain severity level (MPI) of 3.62 ($SD = 1.07$) and mean level of restrictions in participation

(PDI) of 41.80 ($SD = 10.39$). All FM patients fulfilled the 2010 ACR criteria [58] with a mean WPI score of 11.84 ($SD = 3.33$) and mean SS score of 8.96 ($SD = 1.63$). Most commonly reported pain locations were neck (95.9%), shoulder (left side: 89.8%, right side: 91.8%) and back (upper back: 91.8%, lower back: 93.9%).

- INSERT TABLE 1 ABOUT HERE -

Task interference by pain

Before performing RT analyses, errors (2.7%) and outliers were removed. Data with response latencies shorter than 200ms (anticipations) or three SDs above the individual mean RT of correct responses for each trial type were considered outliers and excluded from further analyses (1.6%). Next, a 3 (Somatosensory Stimulus: non-painful vs low painful vs moderately painful) x 2 (Group: FM patients vs healthy controls) repeated measures ANOVA was performed. Results showed a main effect for Somatosensory Stimulus ($F_{(1.78, 170.83)} = 53.50, p < .001, \eta_p^2 = 0.358$) and Group ($F_{(1, 96)} = 8.07, p < .01, \eta_p^2 = 0.078$). There was no interaction effect ($F_{(1.78, 170.83)} = 1.60, ns$; see Figure 2). Planned contrasts showed that participants were significantly slower in performing the visual tasks when receiving moderately ($M = 735.89, SD = 260.24$) compared to low intense painful stimuli ($M = 712.36, SD = 234.04; F_{(1, 96)} = 5.43, p < .05, \eta_p^2 = 0.054, d_{\text{m}} = 0.09, CI = 0.01: 0.17$). Participants were also significantly slower to perform the visual tasks when receiving low intense pain stimuli ($M = 712.36, SD = 234.04$) compared to non-painful stimuli ($M = 620.53, SD = 176.35; F_{(1, 96)} = 65.08, p < .001, \eta_p^2 = 0.404, d_{\text{m}} = 0.39, CI = 0.29: 0.49$). For follow-up correlations (section correlational analyses), an overall pain interference index was calculated by subtracting the average RT on non-painful trials from the mean of the average RTs of low and moderately painful trials. A positive index indicated a delayed response due to the presence of pain, whereas a negative index indicated a speeded response due to the presence of pain.

- INSERT FIGURE 2 ABOUT HERE -

Distraction efficacy

Analyses concerning distraction efficacy were performed on the ratings of all correctly answered pain trials (i.e., 94.1% of all possible pain trial ratings). A 2 (Modality Relevance: somatosensory relevance vs visual relevance) x 2 (Pain Stimulus: low painful vs moderately painful) x 2 (Group: FM patients vs healthy controls) repeated measures ANOVA was performed for pain intensity and unpleasantness. For pain intensity, a main effect was found for Pain Stimulus ($F_{(1, 96)} = 66.46, p < .001, \eta_p^2 = 0.409, d_{rm} = 0.13, CI = 0.10: 0.16$) indicating that participants experienced the moderately intense pain stimulus ($M = 42.79, SD = 23.73$) as more painful than the low intense pain stimulus ($M = 39.66, SD = 22.64$). Also a main effect was found for Modality Relevance ($F_{(1, 96)} = 31.31, p < .001, \eta_p^2 = .25, d_{rm} = 0.08, CI = 0.05: 0.11$), in that participants experienced less pain during visual modality trials ($M = 40.29, SD = 23.00$) than during somatosensory modality trials ($M = 42.15, SD = 23.33$). In contrast to our expectation, there was no interaction-effect between Group and Modality Relevance ($F_{(1, 96)} < 1, ns$). No other main effects or interaction effects were significant (all $F_s > 1.79$). Results for pain unpleasantness were similar such that there was a main effect of Pain Stimulus ($F_{(1, 96)} = 87.98, p < .001, \eta_p^2 = 0.478, d_{rm} = 0.16, CI = 0.12: 0.19$), indicating that participants experienced the moderately intense pain stimulus ($M = 41.63, SD = 23.55$) as more unpleasant than the low intense pain stimulus ($M = 37.92, SD = 22.53$). In addition, we found a main effect for Modality Relevance ($F_{(1, 96)} = 30.91, p < .001, \eta_p^2 = 0.244, d_{rm} = 0.09, CI = 0.06: 0.12$), indicating that pain was perceived as less unpleasant during visual modality trials ($M = 38.71, SD = 22.71$) than during somatosensory modality trials ($M = 40.84, SD = 23.37$). Again, in contrast to our expectation, no interaction-effect was found between Group and Modality Relevance ($F_{(1, 96)} < 1, ns$). No other main effects or interaction effects were significant (all $F_s > 1$). For follow-up correlations (section correlational analyses), a distraction-efficacy index was calculated by subtracting the mean of the average ratings on low and moderately painful visual focus trials from that of the low and moderately painful somatosensory focus trials for pain intensity and unpleasantness ratings, respectively. Given that the distraction-efficacy indices for pain intensity and unpleasantness were highly correlated, an overall pain distraction-efficacy was calculated by averaging both indexes.

- INSERT TABLE 2 ABOUT HERE -

Correlational analyses

In a final exploratory step, we investigated whether task interference by pain and distraction efficacy were related. In addition, we explored their relationship with individual difference variables (e.g., anxiety, pain intensity). For variables measured in both groups, i.e., FM patients and healthy controls, partial correlations were performed to control for the impact of Group. For the variables that were only measured in the FM patient group, Pearson correlations were performed. Correlation analyses showed that the magnitude of distraction efficacy and task interference by pain did not correlate ($r = .06$, ns). Distraction efficacy was, however, negatively related to anxiety (DASS-A, $r = -.18$, $p = .09$), pain catastrophizing (PCS, $r = -.18$, $p = .08$), pain severity (MPI-ps, $r = -.26$, $p = .07$), and fatigue at the moment of testing (fatigue, $r = -.25$, $p = .01$), suggesting that distraction is most effective in people who are less anxious, are low catastrophizing about pain, report less severe pain or are less fatigued, respectively. In contrast, task interference by pain was not related to any of the investigated individual differences variables (see Table 2).

Discussion

This study investigated task interference and distraction efficacy in FM patients, and in a matched healthy control group. The results can be readily summarised. First, we found that pain interferes with task performance in FM patients as well as healthy individuals. Second, participants experienced the pain stimulus as less intense when directing attention away from the pain stimulus (i.e., when performing a visual task) than when focusing on the pain. In contrast to our hypothesis, no difference was found in the magnitude of the interference effect and distraction-efficacy between FM patients and healthy controls. Finally, our findings indicate that the indices of task interference and distraction-efficacy are not related to each other, suggesting that they are not two sides of the same coin.

In line with previous research, the current findings show that pain interferes with task performance in both healthy participants [35,36] and chronic pain patients (e.g., [14]). Indeed, participants' performance on a visual detection task was significantly slowed when receiving a painful in comparison to a non-painful tactile stimulus. Furthermore, to our knowledge the current study is one of the first to show that the interference effect increases with the intensity of the pain stimulus. This finding is in line with earlier theories that state that salient stimuli - i.e., stimuli which are more intense, more threatening, more novel or less predictable - are more likely to capture attention [15,29].

Furthermore, the findings of the current study indicate that distraction from pain may result in reduced experience of a low to moderately intense pain stimulus. Yet, the efficacy of the distraction task was not dependent upon the intensity of the pain stimulus. This finding appears to be in contrast with research suggesting that distraction is more effective for less intense pain [33,54]. It is, however, possible that the difference in the intensity of the pain stimuli (low vs moderately painful) was too small to show the impact of pain intensity upon distraction efficacy. It may also be that there is no linear relationship between pain intensity and distraction efficacy, but that distraction is successful until pain intensity exceeds a certain level of intensity [52]. Contrary to our expectations, groups did not differ in the magnitude of the pain interference effect and distraction efficacy. Although the overall performance of FM patients was slowed, the interference effect of low and moderately intense pain stimuli did not differ from the interference effect in healthy controls. This finding challenges the idea that painful stimuli more easily demand attention in FM patients than in healthy people. Instead, our results suggest that FM patients and healthy volunteers may have similar difficulties performing a primary task when experiencing pain. We did observe a general slowing in task performance in FM patients compared to healthy participants. This is in line with previous research revealing slower reaction times in chronic pain patients than in healthy controls (e.g., [55]). There may be several reasons for this slowed performance. First, the slowed performance may reflect impaired mental processing speed (e.g., [20,30]). Second, it is possible that the slower reaction times can be attributed to motor slowing. Indeed, performing the visual detection task required also a motor response (button press). Slowed motor responses may

for example, be due to the use of medication (or medication history) or reduced general physical fitness levels [13]. Unfortunately, the current study does not enable us to draw firm conclusions about whether the slow response times were due to problems in mental processing or motor speed, or both.

The current findings suggest that distraction is as effective in FM patients as it is in healthy people. This finding contradicts some earlier findings (for an overview [54]) indicating that distraction is not effective or to a lesser extent in chronic pain patients compared to healthy controls. A number of reasons may explain this discrepancy. First, in contrast to most distraction studies in chronic pain patients (e.g., [22]), the experimental pain stimulus was of a short duration and of low to moderate intensity. It may well be that FM patients are able to increase their effort in a distraction task for a short timespan when pain is not too intense (See also [54]). Second, our control condition did not instruct participants to cope with pain as usual, often the case in previous distraction research in chronic pain patients, allowing for large variability in used strategies ([21,22], but see also [45] for an exception). Instead participants were instructed to focus their attention on the pain stimuli (i.e., perform a somatosensory detection task). The fact that the difference in control condition could explain these diverging findings is in line with sub-analyses of a recent meta-analysis [54]. Results of this meta-analysis showed that, although distraction shows to be ineffective when compared with a no-instruction control condition, it does result in a pain reduction when being compared with a condition in which attention is focused on pain. A potential avenue for research is then to investigate to what extent patients with FM spontaneously make use of distraction strategies, and the possible reasons for not doing so. All in all, this finding points at the importance of well thought control conditions in distraction research. Third, it should be noted that although all participants experienced the pain stimuli as moderately painful, the stimulus intensity was substantially lower in FM patients compared to their healthy counterparts. This finding is in line with the central sensitisation hypothesis, which suggests that the responsiveness of central neurons to input from unimodal and polymodal receptors is augmented in FM patients, and results in generalized or widespread hypersensitivity [34,38]. The procedure followed in the current study, to determine individual pain thresholds, differs from most previous

distraction studies in chronic pain patients, in that they mostly used a fixed stimulus intensity for all participants (e.g., [21]). It may thus be that in current study distraction was equally effective in FM patients and healthy controls, because during the calibration phase we identified in each individual the intensity that was experienced as moderately painful. Therefore, at the start of the study, the self-reported intensity of the stimulus was not different between the FM and healthy controls. This approach was deliberate. When using a stimulus of fixed intensity (e.g., [21,22]), experienced pain may be higher in patients with FM than in healthy controls because of differences in low level processes involved in peripheral or central sensitisation. During the calibration phase, we instructed participants to pay close attention to the stimulus. That way, we reasoned that attention to pain was kept constant, and potential differences in the way participants habitually pay attention to pain were ruled out [1]. Future work should further explore this assumption. Finally, we found that the magnitude of task interference by pain is not related to distraction efficacy. This finding suggests that distraction efficacy is not just the counterpart of task interference by pain [50]. Distraction efficacy is based on self-report of pain and may be more prone to expectations of people and/or reporting or reflection biases. This may also explain why only distraction efficacy, and not task interference, was related to self-report measures of pain experience, catastrophizing, anxiety and levels of fatigue in FM patients.

In addition to these theoretical implications, the current findings also have clinical implications. On the one hand, our results indicate that under specific conditions distraction may be useful in FM patients. That is, when pain is not intense and of short duration. It should be noted that our cognitive distraction task only resulted in a small reduction in self-reported pain. As such, the use of distraction strategies should be well-considered. On the other hand, our results also show that distraction may be less effective for FM patients who experience more intense chronic pain, catastrophize about their pain, are more anxious or more fatigued.

This study has some limitations. First, the current study was performed in the lab using experimental pain stimuli. Although the use of experimental pain stimuli increases experimental control, it may be difficult to generalize findings to the everyday life of FM patients. Second, we opted to tailor the intensity of the experimental pain stimulus to an experience of moderate pain.

This resulted in the presentation of pain stimuli, which differed in their (objective) intensity. Other studies have most often used a fixed intensity procedure. Our results may differ from these studies because of this dissimilarity. Third, we did not assess whether the tactile stimulus was perceived as painful by the patients with FM. This is, however, unlikely as no patient mentioned that the tactile stimulus was perceived as painful and unpleasantness ratings of the tactile stimulus were low. There was also no difference in the unpleasantness ratings between FM patients and healthy participants. Fourth, the difference, between low intensity and moderate intensity pain stimuli was relatively small. This may have reduced the chances to find an impact upon distraction efficacy. Future research may opt to increase the difference between the intensity levels of pain stimuli.

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Figure Captions

Figure 1: Schematic illustration of the experimental set-up.

Figure 2. Task interference effect per Group (FM patients vs control group)

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Tables

	Healthy controls (n=49)	FM patients (n=49)	Group difference statistics
Sex (females/males)	40/ 9	41/8	$\chi^2_{(1)} = 0.07, ns$
Age	45.39 (12.07)	45.20 (9.35)	$t_{(90.34)} = .08, ns$
Education level (primary/ lower secondary/ higher secondary/ higher education)	2/ 2/ 19/ 26	2/ 7/ 21/ 19	$\chi^2_{(3)} = 3.97, ns$
Pain intensity (test moment)	2.10 (4.59)	44.08 (21.06)	$t_{(52.56)} = 13.64, p < .001$
PCS	9.88 (9.76)	21.90 (10.77)	$t_{(96)} = 5.79, p < .001$
DASS-A	2.84 (3.48)	11.41 (7.42)	$t_{(68.21)} = 7.32, p < .001$
DASS-D	5.61 (6.25)	13.41 (10.72)	$t_{(77.27)} = 4.40, p < .001$
DASS-S	7.76 (7.24)	15.55 (7.81)	$t_{(96)} = 5.12, p < .001$
BVS	14.19 (6.81)	18.59 (6.71)	$t_{(96)} = 3.22, p < .01$

Table 1. Descriptive statistics per group (FM patients and control group).

	Group	Dis. eff.	DASS- A	DASS- D	DASS- S	MPI- ps	PCS	PDI	BVS	State PI	State fatigue
Task	<i>r</i>	.06	.08	.02	-.03	-.09	-.01	-.19	-.01	-.11	-.12
interference	<i>df</i>	95	95	95	95	47	95	47	95	95	95
Distraction	<i>r</i>	-	-.18 ^t	-.10	-.01	-.26 ^t	-.18 ^t	-.19	-.10	-.14	-.25*
effect	<i>df</i>	-	95	95	95	47	95	47	95	95	95

Table 2. Partial correlations controlled for Group (FM patients vs control group). For the MPI and PDI

which were only assessed in the FM patient sample Pearson correlations are reported.